10.0 TOTAL FORCE FOOT GROUND INTERFACE (TF-FGI)

The Total Force Foot Ground Interface (TF-FGI) will provide a primary means to dynamically measure the total force exerted on each foot by the crewmembers during normal work, training and exercise routines. The hardware will be crew-worn and will interface with other HRF hardware items for data collection purposes.

10.1 HARDWARE DESCRIPTION

The TF-FGI consists of the TF-FGI Box and the TF-FGI Insole Assembly.

10.1.1 TF-FGI Box

The TF-FGI Box consists of a Printed Wiring Assembly (PWA) contained within an aluminum housing. All components, other than external batteries are contained on the single Printed Wiring Assembly. Two alkaline nine-volt batteries provide a minimum lifetime of twelve hours of operation.

The TF-FGI Printed Wiring Assembly is an analog signal conditioning circuit. It interfaces with the Novel insoles, which are used as the sensor, and with the Human Research Facility (HRF) Ambulatory Data Acquisition System (ADAS), which acts as the data acquisition and storage unit. The TF-FGI Printed Wiring Assembly incorporates semi-automatic calibration of the individual insoles through the use of an on board microcontroller. A preliminary diagram for the TF-FGI Box is shown in Figure 10.1.1-1.

Green Light Emitting Diodes (LED) are used to provide a simple calibration menu. A red blinking LED is used to warn of a low battery condition. All LEDs are plastic.

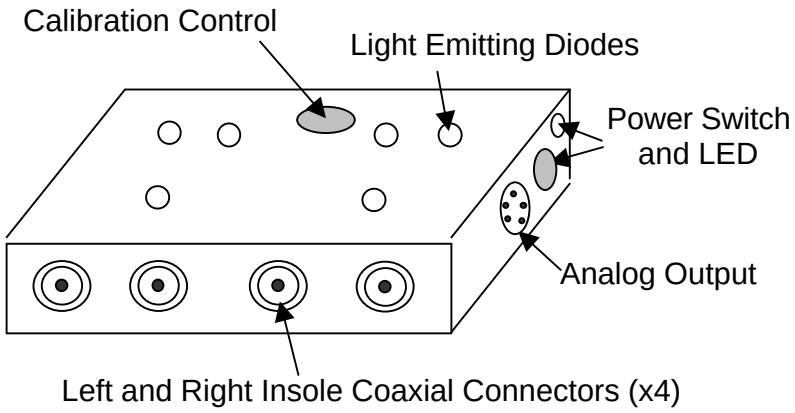

FIGURE 10.1.1-1 TF-FGI BOX DIAGRAM

10.1.2 TF-FGI Insole Assembly

The sensor system that measures the pressure distribution of the foot is a sensor pad that fits in the shoe. This device looks similar to the orthopedic insoles available at a local drug store. This insole is a capacitive measuring device arranged in a matrixed transmitter and receiver system. The transmitter and receiver are separated by an elastomer. As the transmitter emits a signal across the elastomer, the receiver picks up the signal and provides a value to an analog to digital (A/D) converter. As the elastomer is compressed, the distance between the transmitter and receiver is reduced, thus increasing the signal strength at the receiver, thereby providing a larger value at the A/D

converter. The TF-FGI Insole Assembly consists of a pair of Novel insoles (left and right). Each insole consists of 99 individual capacitive pressure sensors distributed over the entire insole surface area. The sensors are contained within the insoles and are not in direct contact with the skin. Compression of the insole surface varies the output signal, which is transferred to the TF-FGI Box via a cable in the Lower Extremity Monitoring Suit (LEMS) (Experiment Unique Equipment, see Chapter 10 of LS-71066). The signal through these cables is 7 volts, approximately 150μA. Two external electrical connectors are used per insole. These insole connectors are embedded in a Silicone RTV molding to prevent disconnection.

A diagram of the Total Force Foot Ground Interface Insole Assembly is shown in Figure 10.1.2-1.

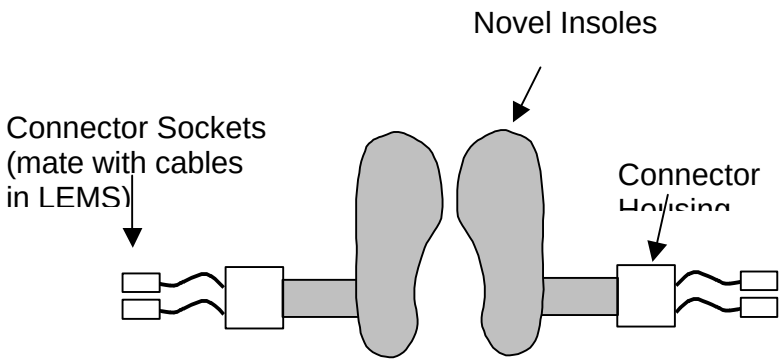

Figure 10.1.2-1 TF-FGI INSOLE ASSEMBLY

10.2 OPERATIONS

10.2.1 Launch/Ascent and Transport to Station

The TF-FGI hardware will be launched in a stowed location. No shuttle services are required during launch or transport.

10.2.2 On Orbit Scenario

The TF-FGI will be used in two operational modes: calibration and data collection.

For calibration of the insoles, the TF-FGI will be used in association with the FGI Flight Calibration Unit (FCU) (see Chapter 11A). The insole to be calibrated is placed within the calibration unit. The FCU is connected to the rack nitrogen interface. The crewmember controls the flow of nitrogen to a bladder within the FCU, exerting a stable, uniform load on the insole. Once a specified pressure level is reached, a calibration button on the TF-FGI box is pressed. The calibration procedure is then repeated for the other insole.

For data collections, the crewmember dons the Lower Extremity Monitoring Suit. The insoles are placed within the crewmember's shoes, and the TF-FGI insole assemblies are connected to cables in the legs of the LEMS. The TF-FGI box is connected to the other end of the cables and to the ADAS. Data output from the insoles is transferred to the TF-FGI Box and then to the ADAS where it will be stored on PCMCIA cards.

10.2.3 Rapid Safing

TF-FGI hardware could be easily removed in a rapid safing situation, but egress to an adjacent module would not be prevented while wearing this hardware.

10.2.4 Fire Protection

Fire prevention is handled in the design process. The TF-FGI is made with approved materials and with proper wire sizing and circuit protection. Elimination of fire sources through conformal coating and electronic parts derating was implemented in the design. Proper grounding is also implemented. While the TF-FGI box is not sealed, it is also not intentionally vented and therefore would be self-extinguishing in the event of an internal fire. Fire detection would be either via the area smoke detector or the crew. Fire suppression would be handled using a Portable Fire Extinguisher (PFE) with the wide area/diffuser nozzle.

10.2.5 Maintenance and calibration

Calibration of the TF-FGI is for scientific purposes and lack of calibration does not present a hazard.
Battery changeout for the TF-FGI box is expected and would entail opening the hinged battery cover on the box and replacing the batteries. No tools are required. No other maintenance is planned or expected.

10.2.6 Aging and disposal

Each crewmember will have a dedicated pair of insoles. These insoles will be changed out as the crew rotates. Insoles would deteriorate over time and have a five year shelf life. Problems would be indicated during setup and/or calibration. The data would be

affected if insoles were used after the shelf life had expired, but no hazards would be created.

10.3 INTERFACE REQUIREMENTS

No critical services are required from the orbiter or ISS for this hardware item.

10.3.1 Power

The TF-FGI box does not require an external power source. Power is received from the 2-9V batteries. There are electrical interfaces from the TF-FGI box to the ADAS and through the LEMS to the insoles. See figure 10.3-1. See figure 10.3-2 for an electrical schematic, including the 9V batteries.

10.3.2 Data

The data from the foot insoles is collected on PCMCIA cards using the ADAS. See figure 10.3-1.

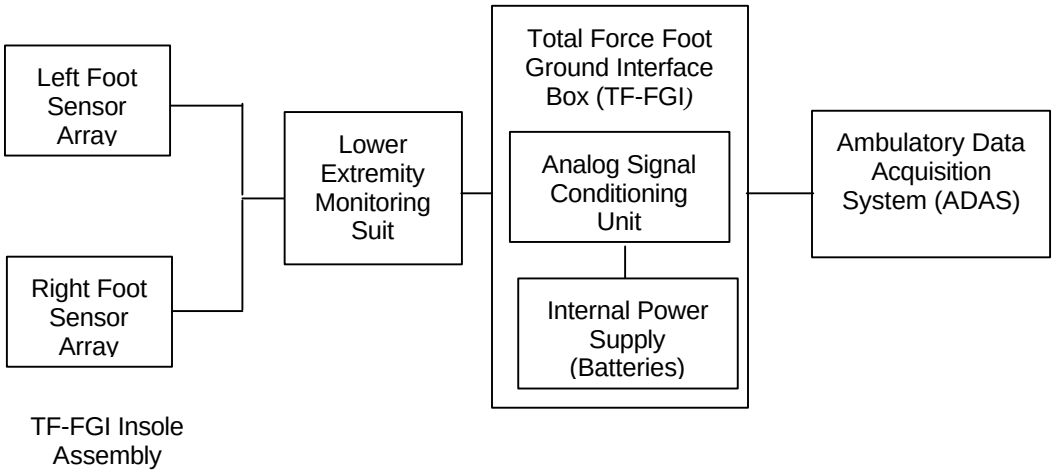

Figure 10.3-1 Electrical/Data Interfaces

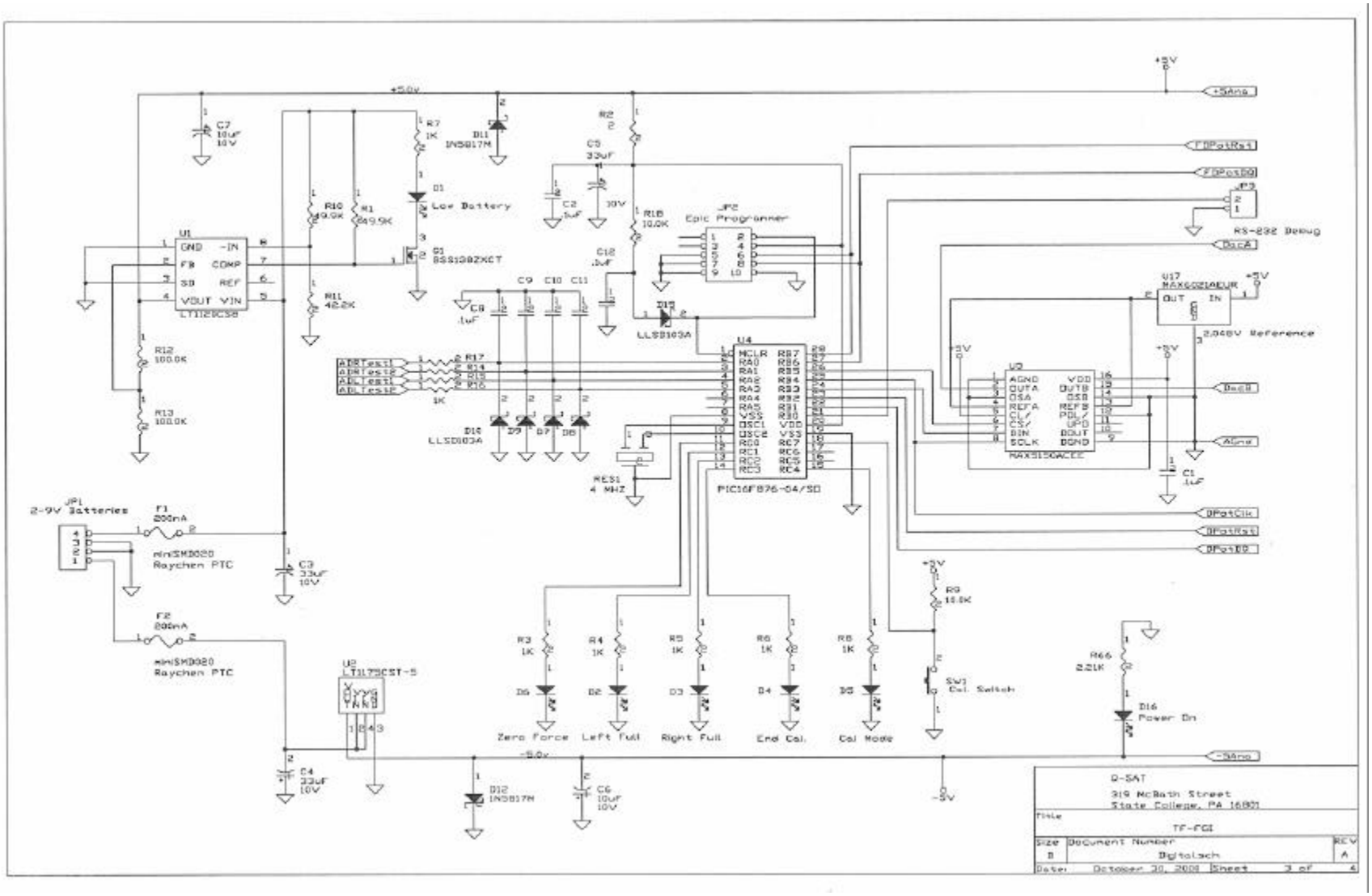

Figure 10.3-5-2 TF-FGI Electrical Schematic

10.4 SAFETY ASSESSMENT

Payload safety critical subsystems are normally subdivided into pressure systems, radiation, mechanical, structural, electrical, human factors, and materials categories for consideration. The following categories are applicable to the TF-FGI and are documented on the Form 1230 in Appendix 10A. A list of hazard controls requiring crew procedures or crew training can be found in Appendix 1D at the front of this document.

10.4.1 Human Factors

Construction of the TF-FGI will meet the requirements specified in SSP 57000, section 3.12.9.2, for sharp edges, corners, or protrusions. No potential pinch points have been identified.

The TF-FGI will meet touch temperature requirements of letter MA2-95-048, “Thermal Limits for Intravehicular Activity (IVA) Touch Temperature”.

10.4.2 Materials

All materials selected for the manufacture and construction of flight hardware and equipment, both metallic and non-metallic, meet the requirements specified in applicable requirements documentation (MSFC-HDBK-527/JSC 09604, “Materials Selection List for Space Hardware Systems”; SSP 30233, “Space Station Requirements for Materials and Processes”; NSTS 1700.7B, “Safety Policy and Requirements for Payloads Using the Space Transportation System”; and NSTS 1700.7 ISS Addendum, “Safety Policy and Requirements for Payloads Using the International Space Station”). JSC/EM2 will

review and approve all materials for the TF-FGI and supply the material certification prior to flight.

No toxic materials are used in conjunction with this hardware item. All LED's used in the TF-FGI design are plastic. There are no shatterable materials associated with this design.

10.4.3 Electrical

The TF-FGI will be in compliance with SSP 30237, "Space Station Electromagnetic Emission and Susceptibility Requirements". EMI compatibility testing will be performed.

All electrical connections will be made per procedures with the power to the TF-FGI turned off.

10.4.4 Batteries

The batteries will follow the guidelines of JSC 20793, "Manned Space Vehicle Battery Safety Handbook," and will be approved for their intended use by the JSC power systems branch.

10.4.5 Rapid Safing

The TF-FGI will meet the rapid safing requirements of Letter MA2-96-190 and will not impede emergency IVA egress into other pressurized volumes.

10.4.6 Safety Re-verifications

No periodic re-verifications are required to ensure safe operation for the life of this hardware item.

10.4.7 Action Items/Non-compliances/Hardware Anomalies

No action items or agreements have been assigned to this hardware item. No non-compliances have been identified with this hardware. No safety-related anomalies have occurred with this hardware item.

Appendix 10A

Standard Hazards Associated with the

Total Force Foot Ground Interface

FLIGHT PAYLOAD STANDARDIZED HAZARD CONTROL REPORT			A. NUMBER	B. PHASE	C. DATE
			STD- TF-FGI	Phase 0/I/II	Dec 2000
D. PAYLOAD, DTO, DSO or RME *(Include Part Number(s), if applicable)*			**HAZARD TITLE**		**E. VEHICLE**
HRF - Total Force- Foot Ground Interface, P/N: see attached			STANDARD HAZARDS		Shuttle/Station
F. DESCRIPTION OF HAZARD:	**G. HAZARD CONTROLS:** *(complies with)*		**H. APP.**	**I. VERIFICATION METHOD, REFERENCE AND STATUS:**	
1. Structural Failure *(payloads must comply with the listed requirements for all phases of flight)*	a) Designed to meet the standard modular locker stowage requirements of NSTS 21000-IDD-MDK or equivalent IDD_____, or b) Stowed in SPACEHAB per MDC91W5023. *Note: Locker and Soft Stowage items only*		☒ ☐	Reference SSP 50321, International Subrack Interface Standard (ISIS) Drawer Specification, limits for weight and c.g. of ISIS drawer with SSCCD approval. Open, expected closure 4/15/01.	
2. Structural Failure of Sealed or Vented Containers	a) Sealed containers must meet the criteria of NASA-STD-5003, contain a substance which is not a catastrophic hazard if released, be made of conventional metals, and have a maximum delta pressure of 1.5 atm. b) For intentionally vented containers, vents are sized to maintain a 1.4 factor of safety for Shuttle or a 1.5 factor of safety for Station with respect to pressure loads.		☐ ☐	N/A	
3. Sharp Edges	Meets the intent of one or more of the following: a) NASA-STD-3000 / SSP 50005 b) SLP 2104 c) NSTS 07700 Vol. XIV App. 7 (EVA hardware) d) NSTS 07700 Vol. XIV App. 9 (IVA hardware) / SSP 57000		 ☐ ☐ ☐ ☒	Sharp Edge Inspection of as-built hardware. To be closed by TPS. Open, expected closure 4/15/01.	

FLIGHT PAYLOAD STANDARDIZED HAZARD CONTROL REPORT		A. NUMBER STD- TF-FGI	B. PHASE Phase 0/I/II	C. DATE Dec 2000
D. PAYLOAD, DTO, DSO or RME *(Include Part Number(s), if applicable)* HRF - Total Force- Foot Ground Interface, P/N: see attached		HAZARD TITLE STANDARD HAZARDS		E. VEHICLE Shuttle/Station
F. DESCRIPTION OF HAZARD:	**G. HAZARD CONTROLS:** *(complies with)*	**H. APP.**	**I. VERIFICATION METHOD, REFERENCE AND STATUS:**	
4. Shatterable Material Release	a) All materials are contained. b) Optical glass (i.e. lenses, filters, etc.) components of crew cabin experiment hardware that are non-stressed (no delta pressure) and have passed both a vibration test at flight levels and a post-test visual inspection. c) Payload bay hardware shatterable material components that weigh less than 0.25 lb and are non-stressed (no delta pressure) or non-structural.	☐ ☐ ☐		
5. Flammable Materials	a) A-rated materials selected from MAPTIS, or b) Flammability assessment per NSTS 22648	☒ ☐	Review/approval of material list by JSC/EM2 Material Branch. Open, expected closure 4/15/01.	
6. Materials Offgassing	a) Offgassing tests of assembled article per NHB 8060.1	☒	Review/approval of offgas testing by JSC/EM2 Materials Branch. Open, expected closure 4/15/01.	
7. Nonionizing Radiation 7.1 Non-transmitters	a) Pass NSTS 21288 / SSP 30237 EMI compatibility testing, or b) NSTS/MS2 approved analysis	☒ ☐	Review of test results for successful completion of EMI compatibility testing. To be closed by TPS. Open, expected closure 4/15/01.	
7.2 Lasers	a) Beams are totally contained at the maximum possible power and there is no crew access, or b) Meet ANSI Z136.1-1993 for class 1, 2, or 3a Lasers (as measured at the source).	☐ ☐	N/A	

FLIGHT PAYLOAD STANDARDIZED HAZARD CONTROL REPORT		A. NUMBER STD- TF-FGI	B. PHASE Phase 0/I/II	C. DATE Dec 2000
D. PAYLOAD, DTO, DSO or RME *(Include Part Number(s), if applicable)* HRF - Total Force- Foot Ground Interface, P/N: see attached		HAZARD TITLE STANDARD HAZARDS		E. VEHICLE Shuttle/Station

F. DESCRIPTION OF HAZARD:	G. HAZARD CONTROLS: *(complies with)*	H. APP.	I. VERIFICATION METHOD, REFERENCE AND STATUS:
8. Battery Failure *(use of this form is limited to small commercial batteries as listed below)* 8.1 Alkaline-MnO_2, Carbon- Zn, or Zn-Air in sizes D or smaller having 6 or fewer cells either all in parallel or all in series (series/parallel combinations require a unique hazard report), no potential charging source, and cells are in a vented compartment. 8.2 Li-CFx, Li-Iodine, Li-MnO_2, Ni-Cd, Ni-MH, or Ag-Zn which have a capacity of 200 mAh or less, and no more than 2 cells per common circuit.	Pass acceptance tests which include open circuit & loaded voltage measurements, visual examination, and leakage check under vacuum (e.g. 6 hours at 0.1 psia). *Note: Above acceptance testing for button cells in Section 8.2 which are soldered to a circuit board in commercial equipment (not applicable to those button cells in a spring-loaded clip) is limited to a functional check of the equipment utilizing the subject battery.*	☒	Battery approval, closed, see attached EP5-00-06. Acceptance testing for 2 9V alkaline batteries within the TF-FGI box. Open, expected closure 4/15/01. *Note: Application and schematic reviewed and approved by JSC/EP5.*
9. Touch Temperature	a) Meets IVA touch temperature criteria of letter, MA2-95-048. b) Meets EVA touch temperature criteria of NSTS 07700 Vol. XIV App. 7.	☒ ☐	Test to ensure surfaces do not exceed 49°C. Open, expected closure 4/15/01.
10. Electrical Power Distribution	a) Shuttle payload - Meets all circuit protection requirements of Letter TA-92-038. b) Station payload - Meets station interface circuit protection requirements of SSP 57000 and payload circuit protection requirements of Letter TA-92-038.	☐ ☐	N/A, no interfaces to ISS power.
11. Ignition of Flammable Atmospheres in Payload Bay	All ignition sources are controlled as required in Letter NS2/81-MO82, and MLI grounded per ICD 2-19001.	☐	N/A
12. Rotating Equipment	Rotating equipment meets criteria of NASA-STD-5003 for obvious containment.	☐	N/A

FLIGHT PAYLOAD STANDARDIZED HAZARD CONTROL REPORT			A. NUMBER STD- TF-FGI	B. PHASE Phase 0/I/II	C. DATE Dec 2000
D. PAYLOAD, DTO, DSO or RME *(Include Part Number(s), if applicable)* HRF - Total Force- Foot Ground Interface, P/N: see attached			HAZARD TITLE STANDARD HAZARDS		E. VEHICLE Shuttle/Station
F. DESCRIPTION OF HAZARD:	**G. HAZARD CONTROLS:** *(complies with)*		**H. APP.**	**I. VERIFICATION METHOD, REFERENCE AND STATUS:**	
13. Mating/demating power connectors	Meets all requirements of Letter MA2-97-093.		☒	Review of crew procedures to verify hardware power switches and power outlet switches are in the "off" position prior to making connections. Open, expected closure 4/15/01.	
14. Contingency Return and Rapid Safing	a) Shuttle payload - Meets all rapid safing requirements of Letter MA2-96-190. b) Station payload - Meets rapid safing requirements of Letter MA2-96-190, and design shall not impede emergency IVA egress to the remaining adjacent pressurized volumes.		☐ ☒	Hardware will not impede emergency egress. Removal of equipment from subject can be accomplished in <30 seconds. CLOSED.	
APPROVAL	**PAYLOAD ORGANIZATION**			**SSP/ISS**	
PHASE I					
PHASE II					
PHASE III					

PART NAME	PART NUMBER
Total Force Foot Ground Interface (TF-FGI)	SEG46118238
TF-FGI Box	SEG46118240
TF-FGI Insole Assembly	SEG46118241